MASTER COPY - FOR REPRODUCTION PURPOSES

AD A 218 597

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) ARO 26415.1-MS
6a. NAME OF PERFORMING ORGANIZATION MIT 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION U. S. Army Research Office
6c. ADDRESS (City, State, and ZIP Code) Cambridge, MA 02139	7b. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAAL03-89-K-0043
8c. ADDRESS (City, State, and ZIP Code) P. O. Box 12211 Research Triangle Park, NC 27709-2211	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Fundamental and Applied Aspects of Defect Engineering in G2As; EL2 and Other Nonstoichiometric Defects

12. PERSONAL AUTHOR(S)
Jacek Lagowski

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 2/15/89 TO 10/14/89	Jan 24, 1990	4

16. SUPPLEMENTARY NOTATION
The view, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Gallium Arsenide Defects, Crystal Growth, Gallium Arsenide Resistivity

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The work constituted an initial part of a 3 year program on "Defect Engineering in GaAs..". This part realized at the Massachusetts Institute of Technology was terminated on October 14, 1989. The work was focused on the role of the EL2 defect and native shallow acceptors in the engineering of GaAs resistivity and thermal conversion characteristics. The program was interrupted by a transfer of the principal investigator (J.L.) to EE Department of the University of South Florida (USF)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) / 22c. OFFICE SYMBOL

Fundamental and Applied Aspects of Defect Engineering in G2As; EL2 and Other Nonstoichiometric Defects

FINAL REPORT

Jacek Lagowski

January 24, 1990

U.S. Army Research Office

DAAL 03-89-K-0043

Massachusetts Institute of Technology

1. Forward

The work constituted an initial part of a 3 year program on "Defect Engineering in GaAs..". This part realized at the Massachusetts Institute of Technology was terminated on October 14, 1989. The work was focused on the role of the EL2 defect and native shallow acceptors in the engineering of GaAs resistivity and thermal conversion characteristics. The program was interrupted by a transfer of the principal investigator (J.L.) to EE Department of the University of South Florida (USF)

2. Results:

The project was initiated on February 15, 1989. In accord with the Statement of Work, our research was focused on the engineering of the EL2 defect in GaAs employing nonstoichiometric crystal growth and annealing rapid cooling treatments. We have completed a series of very high temperature annealing of Ga-rich samples at temperatures only about 10^{0}C below the GaAs melting point. Prior to annealing, Ga-rich samples contained virtually no EL2 (below 10^{15} cm^{-3}) and our experiments were designed to answer the question of whether EL2 can be formed via annealing in As-rich ambient.

Samples were characterized using the near infrared optical absorption in the range 2 to 0.8 mm (whereby characteristic optical transitions via the EL2 defect take place). Very high sensitivity measurements which included optical bleaching and thermal recovery cycling between 4K and 140K showed no EL2 absorption in (0); (1+) and (2+) states at a level exceeding 10^{15} centers/cm^{3}. DLTS measurements of O/(1+) EL2 level (electron, trap) and 1+/2+ level (hole trap) yielded similar results. Therefore we conclude that EL2 is not formed in Ga-rich crystals even during 100 hours long annealing at 1300^{0}C in As overpressure.

We have completed a detailed theoretical analysis of the engineering of GaAs resistivity. In the approach we used our refined empirical relationships between the concentration of a native EL2 double donor and the concentrations of native acceptors determined as a function of engineering parameters, namely, the growth melt stoichiometry and the crystal cooling rate. Residual carbon acceptors were also introduced in our model. The results show that all essential GaAs parameters, i.e., the resistivity value, the semiconducting-semi-insulating transition point, and the margin for heavy metal contaminants, could be controlled by controlling the arsenic atom fraction in the melt and/or the rate of crystal colling between 1000^{0}C and 700^{0}C. The results were presented at the Electronic Materials Conference in Boston, June 19-24, 1989, and they are under preparation for publication in the Journal of Applied Physics. Representative theoretical data are shown in the enclosed figure 1. They are an excellent aggreement with experimental data.

Our experimental study indicated very important role of the native acceptor located at 68mev above the valence band. This single acceptor center becomes dominant under Ga-rich crystals. However the presence of 68 meV acceptor has not been documented by previous measurements. Accordingly we prepared a series of samples suitable for electronic Raman spectroscopy measurements. The measurements were performed by Dr. Wagner at the Fraunhofer Institute in Freiburg, Germany. Results confirmed the presence of 68 meV via observation of new 505 cm^{-1} Raman line corresponding to 1s-2s excitation. The strength of the line correlates with the acceptor concentration determined by us from DLTS measurements. Binding energies estimated from both measurements are also in good agreement. The results are being prepared for publication.

In addition to basic research involvement we have also performed service type tasks supplying unique ITC GaAs samples to other laboratories. A series of samples were prepared, and characterized for the Forth Momuth Laboratory researchers namely Mr. Burk (optical switching) and Dr. Poindexter (paramagnetic resonance study).

3. List of manuscripts submitted or published under ARO sponsorship during this reporting period, including journal references:

J. Lagowski, "GaAs vs. Si--Hopes, Challenges and Defect Engineering," presented at Int'l. Conference on the Physics of Semiconductor Compounds, April 25-29, 1989, Jaszowiec, Poland, to be published in Acta Physical Polonica.

K. H. Ko and J. Lagowlsi, "Reassessment of Native Compensation Mechanism in SI GaAs--The Role of Defect Engineering" presented at Electronic Materials Conference, June 19-24, 1989, Boston, Mass.

4. Scientific Personnel supported by this project and degrees awarded during this reporting period:

J. Lagowski--Principal Investigator
K.H. Ko--Postodoctoral Fellow
J. Di Maria--Engineering Assistant

DEFECT ENGINEERING
OF SI-GaAs

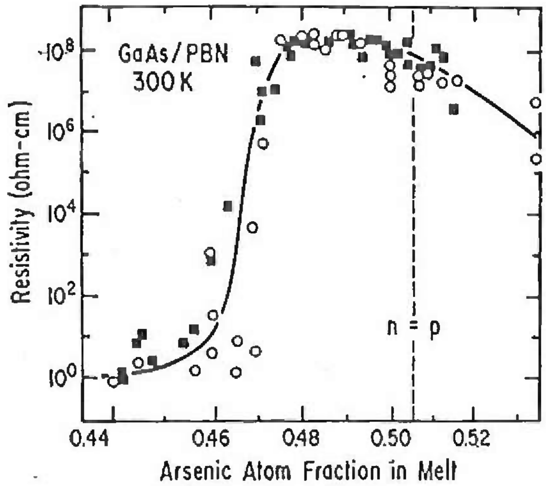
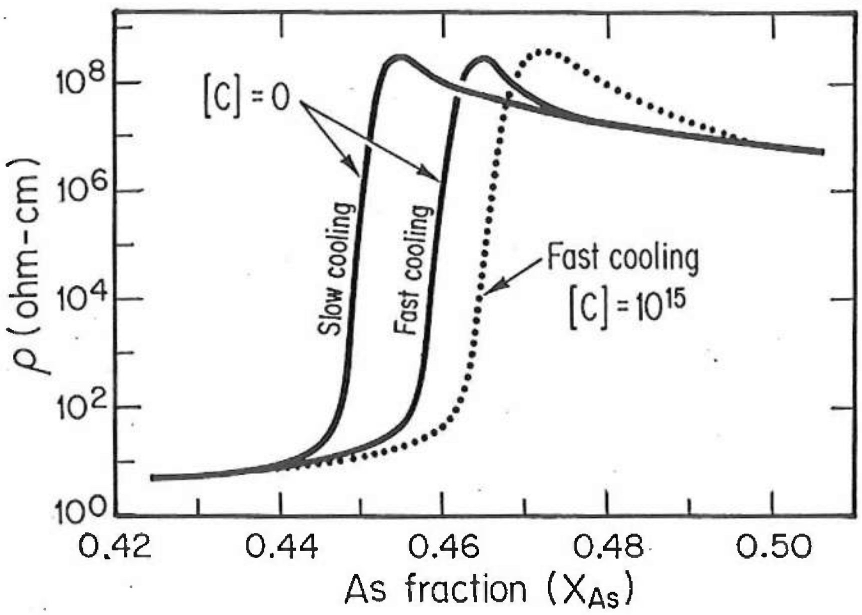


Fig. 1. Resistivity of undoped GaAs grown by the LEC method vs. Arsenic atom fraction in melt.: ■ – results of Westinghouse group ; o – results of Rockwell group.



QUANTITATIVE MODEL FOR MELT GROWN CRYSTALS INCLUDING: COOLING RATE AND MELT STOICHIOMETRY

Fig. 1.